Calendar"; also by a complete "Annual Calendar" for each of the fifty-two years of the Calendar round, and a complete "Chronological Calendar" for three great cycles. In these three great cycles all the dates as yet found in the inscriptions can be located; and, according to Mr. Goodman's theory of a Grand Era of seventy-three great cycles, these three great cycles are numbered the 53rd, 54th and 55th.

No doubt the first objection raised to the scheme will be the improbability of the Mayas having had a chronological system extending over 374,400 years, the number of years composing a Grand Era. And the objection will have all the more force, in that no such time period is mentioned by Landa or any other authority. Mr. Goodman says the Grand Era is a necessity to round off the various time periods on which the Mayas rested their computations. It does not appear to me that this would of itself necessitate a phenomenal antiquity for Maya civilisation, for the Mayas, like every other race, must have been confronted by the question, "When did time begin?" We ourselves have avoided the difficulty by taking a certain point of time, and reckoning forwards from it and backwards until we are lost in the mists of antiquity; but it must be remembered that it is only in the last few years that the date 4004 B.C. has disappeared as a marginal note from the first chapter of Genesis. Is it, therefore, impossible to believe that a people may have reckoned backwards to an imaginary beginning of time, fixed by a purely arithmetical calculation as the point when all the complicated time periods with which they were in the habit of reckoning could have started fair? How those time periods became so complicated, and needed such a vast stretch of time to work themselves out, is another matter—possibly it may have originated from the combination of various methods of reckoning time employed by different branches of the race. However, I must not start theorising on my own account, but refer the reader to the chapter on the "Era and Duration of the Archaic Maya Civilisation," where Mr. Goodman gives reasons for his belief in the great antiquity of Maya civilisation, and shows that between the earliest and latest dates recorded on the sculptures at Palenque there is a difference of 7082 years.

I am so fully aware of my own incompetence to deal with such an abstruse subject as the construction of Calendar systems, that I shall not venture on any critical review of Mr. Goodman's methods or conclusions; but I am glad to have an opportunity of saying that my acquaintance with Mr. Goodman and with his partner in his investigations, Dr. Gustav Eisen, commenced with a correspondence about the drawings of the inscriptions published in the "Biologia Centrali Americana"; and when I was afterwards able again to compare these drawings with the original sculptures, I found that the alterations of form suggested to me with regard to certain obscure and weather-worn minerals and glyphs had nearly always to be confirmed as correct. Then, as Mr. Goodman's methods became more familiar to me, I found myself constantly making use of the results at which he had arrived without any opportunity of acknowledging the source of my information. I was therefore urgent with him to publish the results of his researches, although he lingered fondly over his work, by no means considering it as yet complete.

Since commencing this article a photograph of a carved inscription, lately discovered on the banks of the Rio Usumacinta, has been forwarded to me from Yucatan by Mr. T. Maler. This inscription contains forty-eight glyphs. With the use of Mr. Goodman's tables I am able to locate (in the Maya Calendar) the date expressed in the inscription, and to follow five distinct reckonings to other dates—the reckoning made with the tables giving in every case the same result as that which is expressed in the inscription—and can thus ascertain with certainty the meaning of twenty-two out of the forty-eight glyphs contained in the inscription.

ALFRED P. MAUDSLAY.

## TWENTY YEARS OF INDIAN METEOROLOGY.

SOME years ago, when the Indian Meteorological Service was started, under the directorship of the late Mr. H. F. Blanford, F.R.S., he predicted that the Indian area would yield results second to none in importance in clearing up the mysteries which surround the working of atmospherical conditions. At that time the "Indian Meteorological Memoirs," designed to embody compilations and discussions of data in the spare time of the hard-worked officials of the service, were only just starting.

Six portly volumes of these Memoirs have now been completed since 1876; and, to judge from the character of their contents, and the evident growth of certainty and breadth of view with augmenting experience and improving data, Mr. Blanford's prediction is being fulfilled even more satisfactorily than he could have anticipated.

In 1883 a series of articles, by Mr. Archibald, appeared in NATURE, in which vol. i., containing the first twelve Memoirs, were reviewed at some length. Since that date five more volumes have appeared, containing papers by the late Mr. H. F. Blanford, F.R.S., Mr. Hill, of Allahabad, Mr. Frederick Chambers, Mr. John Eliot, F.R.S. (the present head of the department), Mr. Dallas, and Mr. Archibald. In some of these papers the phenomena dealt with, such as hot winds and special storms, are of purely local incidence. In others, conditions outside the Indian area and their variations over a long course of years are discussed. We shall in the present article direct our attention principally to the light thrown upon the latter in the more recent Memoirs. Before doing this, however, allusion must be made to a very important series of papers, which form a large proportion of these volumes, in which the normal diurnal elements are discussed at twenty-five observatories scattered over the entire Indian area.

The adequate presentation of such normals is of vital importance to the efficient work of the Meteorological Department. To estimate an anomaly or abnormal, we must manifestly be able to refer to a correct normal. One of the points early foreseen by Mr. Blanford, and continually insisted upon by his successor, Mr. Eliot, has been the accurate determination of normals for as many stations as possible over the Indian area. At these twenty-five selected observatories, not merely have the normal means been determined, but the diurnal variations in temperature, pressure, wind, cloud, &c., have been worked out most exhaustively with the guiding aid of the harmonic formula, and the critical epochs determined with no stint of labour by the aid of the analytical process known as Jelinek's method of approximation. The series began with Sibsagar, by Mr. Blanford, on June 16, 1882, and was completed by a special monograph on Calcutta, by Mr. Douglas Archibald, in the present year. The area represented by these observatories extends in longitude from Aden to Dhubri in Assam, and in latitude from Leh in Thibet to Trichinopoly in Southern India. Many valuable points in connection with diurnal variations have been determined and discussed; and if ever the vexed problem of the cause of the daily variation in atmospheric pressure is completely solved, it will only be by the aid of this valuable series of papers.

In the Calcutta Memoir, which has only just reached us, the discussion embraces the temperature, pressure, and humidity observations, registered autographically during the thirteen years 1881–1893, not merely with regard to the diurnal, but also the monthly and annual variations, together with a comparison of results at the other stations. This is probably one of the first complete discussions ever made of autographic records.

By adding on these thirteen years to the previous period of eye observations, a period is obtained sufficiently long to exhibit any secular periodicity, such as that in the mean sunspot period.

In the case of tropical air temperature, the existence of such a period is so well known that it has been frequently pointed out by Blanford, Eliot, and Hill in these Memoirs.

In the case of barometric pressure, as Mr. Blanford pointed out some years ago in his memorable discussion of the barometric see-saw between Siberia and Indo-Malaysia in the sunspot period, there is a small periodic variation of the barometric pressure of such a character that over India the pressure is above the normal in years about the minimum epoch of sunspots, and below it near those of maximum.

Calcutta, as Mr. Archibald states, is too near the axis of the see-saw (which is probably a little to the north of the Himalaya) to show a very marked variation; but the following figures for the mean cycle show that it has an existence, and must be reckoned with as a factor in the prevalent character of the weather in different years:—

*Mean Annual Barometric Pressure anomaly at Calcutta (Alipore) in the eleven-year sunspot cycle from* 1853 *to* 1893.

| | Years of cycle. | | Mean anomaly of annual barometric pressure unsmoothed. Inches. | |
|---|---|---|---|---|
| (1) | 1853 | | – ·0067 | |
| (2) | 1854 | | + ·0007 | |
| (3) | Two cycles intervene. | | + ·0132 | Min. sunspot. |
| (4) | | | + ·0077 | |
| (5) | | | – ·0012 | |
| (6) | | | + ·0042 | |
| (7) | | | – ·0032 | |
| (8) | | 1893 | – ·0067 | Max. sunspot. |
| (9) | | | – ·0100 | |
| (10) | | | – ·0060 | |
| (11) | | | – ·0013 | |

These minute variations of pressure might appear too small to be associated with air movements and conditions of any considerable magnitude. It must, however, be remembered, especially by English meteorologists, that the barometric oscillation, corresponding to any given air-motion, is a direct function of the deflecting force of the earth's rotation, and therefore of the latitude. Consequently, a variation which would represent an insignificant disturbance in latitude 50° might be attended with serious consequences in India.

Thus the only marked feature of the great Madras drought and famine of 1876-77 was a slight excess of pressure over the whole area of drought, which nowhere exceeded ·04″ or ·05″ in amount.

The abnormal pressure conditions which enabled the Indian weather department to foretell accurately the last serious drought in India—that of 1891 in Rajputana—were small in amount, depending on variations and anomalies not exceeding ·05″, which is little more than one-third of the amount of the regular diurnal change between 10 a.m. and 4 p.m.

The range of pressure for the mean cycle for Calcutta in the present case is ·02″, and since the extreme range of annual means is only ·06″, it may be fairly presumed that the cyclical variation bears a sensible ratio to the variations which cause effective changes in the character of the years and seasons. When we further recollect the well-recognised fact that in Northern India the sunspot variations affect the summer and winter oppositely as regards rainfall, no doubts need be entertained that the state of the solar surface coincides with variations which are just as real, and probably no less practically important in their results, than those introduced by the diurnal and seasonal position of the sun in the sky.

It is indeed impossible to live in the tropics without being sensible of the reality of the sunspot influences. In years about the minimum spot epoch the mean annual temperature of the air is from one to two degrees higher, the range is increased, the wind force greater, and the rainfall less and more irregularly distributed than about the maximum epoch. Moreover, though the total sunspot effects are only a part of what occurs and are often masked by certain larger variations, whose origin is probably terrestrial and reactionary rather than solar and direct, the relation is recognised officially as a factor of practical importance, and allowed for in drawing up the forecasts of the summer and winter monsoons.

The whole subject of secular changes has received a decided impetus of late from the Memoir, Vol. vi. Part 2, on "Certain Oscillatory Changes of Pressure of Long and Short Period," by Mr. John Eliot, F.R.S. In this Memoir attention is drawn to a remarkable series of long-period waves of pressure over the Indian area, which vary from six months to two years in duration. The period investigated extends from 1875 to 1894.

These waves are believed to be of the nature of advances or checks in the general oscillatory system of air flow across the equator, which represents the so-called south-west and north-east monsoon winds of the Indian area.

As Mr. Eliot observes: "In part they are probably determined by seasonal conditions in Southern and Central Asia, and in part assist in determining the seasonal conditions in India, and perhaps also in Central Asia."

The extreme range of these fluctuations, measured by monthly abnormals over the whole period, amounts to about 0·118″, or about the same as the diurnal pressure range at sea-level in tropical India.

In discussing these waves, Mr. Eliot exhibits a similar series of oppositely phased oscillations in what are termed the vertical pressure anomalies between pairs of stations situated at considerable elevations in the Himalaya and on the adjacent plains.

These vertical anomalies (which are simply the variation at the hill stations *minus* the variation at the plain stations) are now so successfully employed in the preparation of the forecasts of the winter rains of Northern India, that they demand a little special reference.

In a country like India, where climatic changes far outweigh ephemeral weather changes, it is found that 95 per cent. of the irregular ephemeral changes of pressure are less in amount than the normal diurnal pressure range, the air movements are slow, massive, and regular in contrast with those of higher latitudes, and due quite as much to vertical as horizontal changes. It is therefore to be expected that the density or pressure of the lower mass of air between the hill stations at 7000 feet and sea-level, will often show variations of an entirely opposite character to that of the air above. In other words, abnormally high pressure below argues abnormally low pressure above, and *vice versâ*. As a matter of experience, this is found to be almost invariably the rule. When the pressure at the upper levels is lower than usual, the vertical anomalies would be *negative*, and when higher they would be *positive*. Mr. Eliot finds, moreover, that the vertical anomaly waves between stations such as Leh and Lahore, Murree and Peshawar, correspond all through to the long-period waves at the stations on the plains, but are exactly reversed in phase.

This shows either that the variation of flux is entirely confined to the lower atmosphere, or else that the vertical up and down flow remains temporarily uncompensated at the higher levels. In any case, the conclusion is irresistible that the pressure variations are due to *flow* and not to a mere tidal rise and fall of the entire atmosphere.

A further proof that these so-called waves are connected with the seasonal transfers of air between Asia and the Indian Ocean, is the remarkable fact that the pressure variations at Mauritius are exactly contrary to those on the Indian plains, and *in general* similar to those of the vertical anomalies. In other words, the lower atmosphere over the Southern Indian Ocean and the higher Indian air strata are analogous termini of the harmonic oscillations in the general convective interflow over the monsoon and trade-wind area of Southern Asia and the Indian Ocean.

The chief critical epochs of both the vertical anomaly and general pressure anomaly curves observed over the plains, occur in March and November. These are, therefore, the months when the character of the ensuing season may be partially forecasted from an inspection of the pressure curves.

Experience has shown, as Mr. Eliot says, that "the primary maximum values of these oscillations [*i.e.* of the pressures on the plains] occur at the end of cold weather periods, characterised by abundant or excessive precipitation in Upper India and the Western Himalayas, and that the primary minimum values occur near or at the end of south-west monsoon periods during which the rainfall has been more abundant than usual."

If we remember that the cold weather rains occur in a stratum which mostly lies above the upper stations, and that the general variations above and below are almost invariably opposite in character, the empirical rule simply embodies the rational fact that the maximum rainfall occurs in connection with the minimum pressure of the containing air-stratum. Also since the vertical anomaly and plain pressure curves are inverse to each other, the rule may be put thus.

A descending vertical anomaly curve commencing about November, and a descending plain pressure anomaly curve commencing about March, indicate respectively the probability of heavy winter and summer rainfalls. Ascending curves commencing about the same epochs indicate the reverse seasonal conditions.

In the empirical form, these relations are now being successfully employed by the Indian Meteorological Department in its system of seasonal forecasts.

The marked tendency to a semi-annual or multiple semi-annual variation in the general pressure anomalies is curiously analogous to a similar period in cirrus bands noticed by Weber, in solar and lunar halos by Tromholdt, in the aurora Polaris, and in the spots and prominences on the sun.

What causes the equally marked differences which characterise the incidence of these barometric movements and their attendant conditions in different years, is still a mystery. Like most meteorological phenomena, they are probably a resultant of several components, solar, terrestrial, direct, and reactionary.

In any case, it is evident that the general outcome of these Indian meteorological researches, so far as relates to the question of long-period and universal weather changes, is decidedly encouraging, since it is plain that the majority of the anomalies in the Indian area are resoluble into harmonic periodic elements, leaving only a small residual to be labelled non-periodic and unpredictable. The moral, therefore, is not merely to extend terrestrial observation and the discussion of data over wide areas on broad, rational methods, but to endeavour to discover the precise way in which solar changes produce analogous long and short changes in terrestrial weather, especially where, as in India, these relations form such a dominant proportion of the total.

Since the above was written Mr. Eliot's interesting article on "Periodic Variations of Rainfall in India" has appeared.

Referring as it does particularly to the remarkable wave of rain and drought which has occurred during the past five years, it chiefly emphasises the remark made above, that the yearly anomalies in the general meteorological conditions are the resultant of several components —local, general, terrestrial, solar, direct, and reactionary. From the evidence adduced therein regarding the Indian Ocean area, and a general survey of conditions which have obtained in other parts of the world, it appears that this large oscillation has been of world-wide incidence. That it represents something in addition to the ordinary variations in the oscillatory flow of the trade-monsoon currents across the equator in the Indian Ocean. That it is therefore due to some abnormal extra-terrestrial—probably solar—influence, which must be referred to the solar physicists for its solution.

At the same time, its occurrence in no way invalidates the preceding conclusions deduced from a study of the ordinary yearly variations, or weakens the value of Mr. Eliot's vertical anomaly rule, as an empirical criterion of general monsoon characteristics.

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## MR. NEY ELIAS.

THE name of Mr. Ney Elias, whose death we briefly announced on June 17 (p. 159), is perhaps less familiar to the readers of travel and geography of to-day than it was to similar students of a quarter of a century since. In 1873 the Council of the Royal Geographical Society awarded him the Founders Medal for the successful accomplishment of a most remarkable journey through Western Mongolia. This was a district that no European had traversed since the days of Marco Polo, and notwithstanding the numerous difficulties which Mr. Elias overcame, and the personal danger in which he often stood, he was able to execute unaided a survey of the whole country travelled. The distance travelled was more than 2000 miles, starting from Kalgan, across the desert of Gobi, thence westerly to the Chinese frontier town Kwei-hua, and onward in a north-westerly direction to the Khangai range. The fanatical Mahommedan Mongol tribes, who were at war with the Chinese garrisons, prevented him journeying further to the south, to Kuldja, which was his proposed destination. The murderous devastation occasioned by this insurrection, and the impossibility of securing adequate assistance, compelled him to cross the Russian frontier and seek shelter at the town of Büsk. This journey, which he accomplished in about six months, was not his first experience in China. In 1871 he set out, with a single Chinese servant, to cross the entire continent of Asia, and a few years earlier had penetrated far into the interior with the view of discovering the causes that had forced the Lower Yellow River to forsake its bed and seek a new outlet to the sea. According to Chinese history, this river flowing through the great eastern plain of the country has had a very restless and eventful career. Nine times, within Chinese records, this river has varied its course, and sought a fresh estuary. The positions of the various mouths are scattered up and down the coast, covering, on the whole, five degrees of latitude. The date of the most recent of these fitful excursions is somewhat uncertain, but Mr. Elias concluded, from the observations which he made in 1867, that the change of bed was due to continuous flooding of the country in 1851-2-3, by which various barriers were broken down and changes of level produced. Mr. Elias was subsequently employed in India, and sent to Yunnan and Ladak; also undertaking a mission to Chinese Turkestan. Mr. Elias was a skilled observer in many branches of physics, and in the course of his travels enriched science by many observations. At